DESIGN OF KINEMATIC DRIVE SYSTEMS WITH A NON-STANDARD STRUCTURE.

Assoc. Prof. Mukhiddinov Z.N., Master's 2nd-year student Rakhmatillaev J.Kh.
Tashkent State Technical University after Islam Karimov

In the main drive and feed drives of metal-cutting machines, in addition to single-speed ones, multi-speed alternating current motors with stepwise variation of rotational speed are also often used.

To ensure a standard geometric series of rotational speeds (or numbers of double strokes of feeds), only motors whose rotational speed changes by a factor of 2 when switched can be used. For example: 750/1500; 1500/3000; 750/1500/3000 rpm, i.e., they form a series with $\varphi_e = 2$.

A multi-speed electric motor replaces one group of gear transmissions in the speed gearbox; therefore, it is considered as a fictitious group or an "electric group" with the number of speed steps p_e equal to the number of its speeds and with characteristic x_e.

Since $\varphi_e = 2 = \varphi^{x_e}$, then…

$$x_e = \frac{\log 2}{\log \varphi} \quad (1)$$

The structural formula of a drive with a multi-speed motor has the form:

$$z = p_e(x_e)p_1(x_1)p_2(x_2)\dots p_m(x_m) \quad (2)$$

The total number of speed steps of a drive with a multi-speed electric motor is $z=p_e \cdot z_k$, where z_k is the number of speed steps of the gear gearbox. Consequently, the use of such a motor simplifies the mechanical part of the drive. However, a multi-speed motor is more expensive, and its selection must be economically justified.

For each standard value of φ, the characteristic x_e has a specific value; therefore, the switching sequence of the electrical group depends on φ (see Table 1).

Table 1.

Dependence of the characteristic and the switching sequence of the electrical group on φ

φ	1,06	1,12	1,26	1,41	2
x_e	12	6	3	2	1
Switching sequence of the electrical group					
p_e	$p_{II}p_{III}$	p_{II}	p_I	p_I	p_o

For φ = 1.58 and φ = 1.78, the characteristic x_e is expressed as a fractional number, which makes it impossible to use multi-speed motors.

The use of multi-speed motors imposes the following constraints on the drive structure:

- the electrical group, being the source of energy, is always placed first in the arrangement, i.e., $p_e=p_I$
- the switching sequence of the electrical group (p_o, p_I and etc.) depends on the value of φ;

- the number of gear ratios in the groups preceding the electrical group also depends on φ.

Example: construct the structural formula of a drive if z=12, p_e=2, φ=1.41. In this case, x_e=2, therefore the electrical group must be the first range group, and the main group must have two gear ratios. These conditions are satisfied by two possible variants of the drive structure: z=2(2)2(1)3(4) and 2(2)3(4)2(1), neither of which is feasible, since the regulation range of the second range group in both cases is $R_{pII} = 1{,}41^{(3-1)4} = 1{,}41^8 = 16$, which exceeds the permissible value.

If, in the given example, we take φ=1.26, then the following variants become feasible:

z=2(3)3(1)2(6), z=2(3)2(6)3(1), of which the first is preferable.

The structural diagram for this variant is shown in Fig.1. In this diagram, the fictitious transmissions of the electrical group are conventionally represented by dashed lines, which may be omitted.

The speed (rotational frequency) diagram of the drive is constructed in the same way as for a single-speed motor.

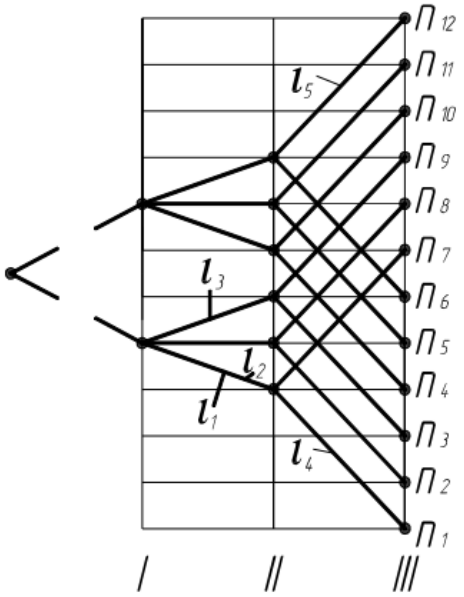


Fig. 3.14. Structural diagram of a drive with a multi-speed electric motor

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